[001] # MULTI-SPEED GEARBOX

[002]

[003]

[004] The present invention concerns a multi-step reduction gear in planetary construction, especially an automatic transmission for a motor vehicle in accordance with the preamble of claim 1.

[005]

[006] Automatic transmissions, especially for motor vehicles, include planetary gear sets according to the state of the art, which are shifted using friction or shifting elements, such as clutches and brakes, and are usually connected with a starting element subject to a slipping action and are optionally provided with a bridging clutch, such as a hydrodynamic torque converter or a hydraulic clutch.

[007] A transmission of this type emerges from EP 0 434 525 A1. It basically includes a drive shaft and an output shaft, which are arranged parallel to each other, and a double planetary gear set arranged concentrically in relation to the output shaft, and five shifting elements in the form of three clutches and two brakes, whose selective blockage respectively determines in pairs the various gear ratios between the drive shaft and the output shaft. Hereby, the transmission has a control gear and two power paths, so that six forward gears can be attained through the selective engagement in pairs of the five shifting elements.

[008] Hereby two clutches are needed in connection with the first power path to transmit the torque from the control gear set to two elements of the double planetary gear set. These are basically arranged behind the control gear set in the direction of the double planetary gears in the direction of the flow of force. A further clutch is provided in connection with the second power path, which detachably connects this with a further element of the double planetary gears. Hereby the clutches are arranged in such a way that the internal disk support forms the output.

[009] Furthermore, a compact multi-step reduction gear in planetary construction, especially for a motor vehicle, is known from the publication US 6,139,463, which

has two planetary gears and a control gear set, as well as three clutches and two brakes. Two clutches C-1 and C-3 are provided with this known multi-step reduction gear in connection with a first power path for transmitting the torque from the control gears to the two planetary gears. Here the external disk support or the cylinder or the piston or the pressure compensation side of clutch C-3 is connected with a first brake B-1. Moreover the internal disk support of the third clutch C-3 is connected with the cylinder or piston or pressure compensation side of the first clutch C-1, whereby the internal disk support of the first clutch C-1 is arranged on the output side and is connected with a sun wheel of the third planetary gear set.

[010] Moreover, a multi-step reduction gear is known from DE 199 49 507 A1 of the Applicant, in which two non-shiftable control gears are provided on the drive shaft, which generate two RPMs on the output side that can, in addition to the RPM of the drive shaft, be shifted electively to a shiftable double planetary gears acting on the output shaft through selective closing of the shifting elements used in such a way that in each case only one shifting element of the two shifting elements just activated must be engaged or disengaged for shifting from one gear into the respectively next following higher or lower gear.

[011] Furthermore, an automatically shiftable motor vehicle transmission with three single rod planetary gears, as well as three brakes and two clutches for shifting from six forward gears and one reverse gear and, with a drive as well as an output shaft, is known from DE 199 12 480 A1. The automatically shiftable motor vehicle transmission is constructed in such way that the drive shaft is directly connected with the sun wheel of the second planetary gear and that the drive shaft can be connected with the sun wheel of the first planetary gears through the first clutch and/or through the second clutch with the rod of the first planetary gears. In addition or as an alternative, the sun wheel of the first planetary gears can be connected through the first brake with the housing of the transmission and/or the rod of the first planetary gears through the second brake with the housing and/or the sun wheel of the third planetary gears through the third brake with the housing.

[012] The present invention is based upon the objective of proposing a multi-step reduction gear of the type stated at the beginning in which the construction expenditure is optimized and, moreover, the degree of efficiency in the main driving gears is improved with respect to drag and gearing losses. Additionally, low torques should be acting on the shifting elements and planetary gears in the multi-step reduction gear of the invention and the RPMs of the shafts, shifting elements and planetary gears should be kept as low as possible. Furthermore, the number of gears as well as the transmission ratio spread should be increased.

[013] This objective is accomplished in accordance with the invention through the features of patent claim 1. Further advantages and refinements will emerge from the dependent claims.

[014]

[015] Accordingly, a multi-step reduction gear in planetary construction of the invention is proposed, which has a drive shaft and an output shaft, which are arranged in a housing. Furthermore, at least three single rod planetary gears, at least seven rotating shafts, as well as at least six shifting elements including brakes and clutches, are provided; the selective engagement of which effects various reductions between the drive shaft and the output shaft so that preferably seven forward gears and one reverse gear can be realized.

[016] In accordance with the present invention, in connection with the multi-step reduction gear, it is provided that the drive is effected through a shaft, which is continuously connected with the sun wheel of the first planetary gears and, in such a way, the output is effected through a shaft, which is connected with the annulus of the second planetary gears and an element of the third planetary gears. Furthermore, the multi-step reduction gear of the invention provides that a third shaft is continuously connected with the rod of the first planetary gears; a fourth shaft is continuously connected with the rod of the second planetary gears as well as a further element of the third planetary gears; a fifth shaft is continuously connected with the annulus of the first planetary gears; a sixth shaft is continuously connected with the sun wheel of the third planetary gears; a seventh shaft is

continuously connected with the sun wheel of the second planetary gears, whereby the planetary gears are coupled by means of shafts and shifting elements.

[017] In the framework of a preferred embodiment, the output shaft is connected with the annulus of the second planetary gears and the annulus of the third planetary gears whereby, in this case, the fourth shaft is connected with the rod of the second and the rod of the third planetary gears and the first planetary gears and the second planetary gears are constructed as negative planetary gears and the third planetary gears as positive planetary gears.

[018] In accordance with a further embodiment, the output shaft is connected with the annulus of the second planetary gears and the rod of the third planetary gears whereby, in this case, the fourth shaft is connected with the annulus of the third planetary gears and the rod of the secondary planetary gears. Hereby the three planetary gears are constructed as negative planetary gears.

[019] Several suitable reductions, as well as a considerable increase of the overall spread of the multi-step reduction gear, are the result of this configuration of the multi-step reduction gear in accordance with the invention, owing to which an improvement in driving comfort, and a significant reduction in consumption are brought about.

[020] The multi-step reduction gear of the invention is suitable for any motor vehicle, especially for passenger cars and for commercial motor vehicles, such as for example, trucks, busses, construction vehicle, rail vehicles, caterpillar vehicles and the like.

[021] In addition, the construction expenditure is significantly reduced with the multi-step reduction gear of the invention because of the low number of shifting elements, preferably four clutches and two brakes. With the multi-step reduction gear of the invention, it is advantageously possible to conduct a start with a hydrodynamic converter, an external starting clutch or also with other suitable external starting elements. It is also conceivable to enable a starting procedure with a starting element incorporated into the transmission. Preferably a shifting element, which is activated in first gear and in reverse gears, is suitable.

[022] In addition, the multi-step reduction gear of the invention results in a good degree of efficiency in the main driving gears with respect to drag and gearing losses.

[023] Moreover, low torques are present in the shifting elements and the planetary gears of the multi-step reduction gear, owing to which, the wear and tear on the multi-step reduction gear, is advantageously reduced. Furthermore, due to the low torques, a correspondingly small dimensioning is made possible, owing to which the space required and the corresponding costs, can be reduced. In addition, low RPMs are also present in the shafts, shifting elements and planetary gears.

[024] Furthermore, the transmission of the invention is designed in such a way that an adaptability to different power train configurations in the direction of the force flow, as well as with respect to space, is made possible.

[025]

[026] The invention will be explained in greater detail below by way of example on the basis of the drawings, wherein:

[027] Fig. 1 represents a schematic view of a preferred embodiment of a multi-step reduction gear of the invention;

[028] Fig. 2 represents a schematic view of an additional preferred embodiment of a multi-step reduction gear of the invention and;

[029] Fig. 3 represents a shifting diagram for the multi-step reduction gear of the invention in accordance with Fig. 1 and Fig. 2.

[030]

[031] Fig. 1 shows the multi-step reduction gear of the invention with a drive shaft 1 (An), and an output shaft 2 (Ab), which are arranged in a housing G. Three single rod planetary gears P1, P2, P3 are provided. Here the first planetary gears P1 and the second planetary gears P2 are constructed as negative planetary gears. The third planetary gears P3 are constructed as positive planetary gears in accordance with the invention. It is also possible that the second

planetary gears P2 and the third planetary gears P3 are combined as Ravigneaux planetary gears with common rod and common annulus.

[032] As is apparent from Fig. 1 and 2, only six switching elements, namely, two brakes 03, 04, and four clutches 14, 16, 37 and 57 are provided.

[033] A selective shifting of seven forward gears and one reverse gear can be realized by means of the shifting elements. The multi-step reduction gear of the invention accordingly consists of a total of seven rotating shafts, namely, the shafts 1, 2, 3, 4, 5, 6, and 7.

[034] In accordance with the invention, it is provided with the multi-step reduction gear, in accordance with Fig. 1, that the drive takes place through shaft 1, which is continuously connected with the sun wheel of the first planetary gears P1. The output takes place through shaft 2, which is connected with the annulus of the second planetary gears P2 and the annulus of the third planetary gears P3. Furthermore, shaft 3 is continuously connected with the rod of the first planetary gears and shaft 4 is continuously connected with the rod of the second planetary gears P2 and the rod of the third planetary gears P3. In addition, shaft 5 is continuously connected with the annulus of the first planetary gears P1. The further rotating shaft 6 is continuously connected with the sun wheel of the third planetary gears P3 and the shaft 7 with the sun wheel of the second planetary gears P2 in accordance with the invention.

[035] With the multi-step reduction gear of the invention, the shaft 3 can be coupled onto the housing G through the brake 03, and the shaft 4 through the brake 04. The clutch 14 connects shaft 1 and shaft 6 detachably with one another. Shaft 1 and shaft 6 are detachably connected with each other through clutch 16. Furthermore, clutch 37 detachably connects shafts 3 and 7, and clutch 57 detachably connects shafts 5 and 7 with each other.

[036] A further embodiment of the multi-step reduction gear of the invention is shown in Fig. 2. Hereby, the planetary gears P1, P2 and P3 are constructed as negative planetary gears. A further difference from the embodiment of Fig. 1 consists in that the output shaft 2 is connected with the annulus of the second planetary gears P2, and the rod of the third planetary gears P3, and in that shaft 4

is continuously connected with the rod of the second planetary gears P2 and the annulus of the third planetary gears P3.

[037] A shifting diagram of the multi-step reduction gear of the invention in accordance with Fig. 1 and 2 is represented in Fig. 3. Respective reductions i of the individual gear stages, and stage progressions φ to be determined on the basis of them, can be inferred by way of example. Furthermore, it can be inferred from the shifting diagram that double shifts can be avoided with sequential modes of shifting, since two adjacent gear steps respectively use two shifting elements in common.

[038] The brake 03 is continuously closed for the seven forwards gear. In addition, brake 04 and clutch 57 are activated for the first gear; for second gear, brake 04 and clutch 16; for the third gear, clutch 16 and clutch 57; for the fourth gear, clutches 16 and 37; for the fifth gear, clutches 14 and 16; for the sixth gear, clutches 14 and 37; and for the seventh gear, clutches 14 and 57. In reverse gear R, brake 04 and clutches 37 and 57 are activated as shift elements.

[039] In accordance with the invention, it is possible to provide additional free wheelings at each suitable position of the multi-step reduction gear, for example, to be connected between a shaft and the housing or about two shafts if need be.

[040] Moreover, it is possible through the mode of construction of the invention to arrange the drive and output on the same side of the transmission or the housing preferably for transverse, frontal, longitudinal, back longitudinal or all wheel arrangements. Moreover, an axle differential and a distributor differential can be arranged on the drive side, or on the output side.

[041] The drive shaft 2 can be separated by a clutch element from a drive motor, as needed, within the framework of an advantageous further development, whereby a hydrodynamic converter, a hydraulic clutch, a dry starting clutch, a wet starting clutch, a magnetic powder clutch or a centrifugal force clutch can be used. It is also possible to arrange a starting element of this type behind the transmission in the flow of force direction whereby, in this case, the drive shaft 1 is continuously connected with the crankshaft of the motor. The start up can take place using a

shifting element of the transmission. Preferably the brake 04, which is activated in the first forward gear, as well as in the first reverse gear, can be used.

[042] The multi-step reduction gear of the invention enables the arrangement of a torsion vibration damper between motor and transmission.

[043] A wear-free brake, such as a hydraulic or electric retarder or the like, can be arranged on any shaft, preferably on the drive shaft 1 or the output shaft 2, which is especially of significance for use in commercial motor vehicles within the framework of a further, not represented embodiment. Furthermore, an auxiliary output can be provided preferably on the drive shaft 1 or the output shaft 2 for driving additional units on each shaft.

[044] The shifting elements used can be constructed as load-shifting clutches or brakes. In particular, force-locking clutches or brakes such as disk clutches, strap brakes and/or cone clutches, can be used. Furthermore, form-locking brakes and/or clutches, such as synchronizations or claw clutches, can be used as shifting elements.

[045] A further advantage of the multi-step reduction gear presented here consists in that an electric machine can be installed on each shaft as generator and/or as additional drive machine.

[046] The functional features of the claims can be constructionally built in more different types of ways. These constructional development possibilities are not being explicitly described for the sake of simplicity. Obviously, each constructional development of the invention, nonetheless, falls under the scope of protection of the claims, especially any spatial arrangement of the planetary gears or the shifting elements in themselves or toward one another and to the extent to which they are technically appropriate.

Reference numerals

1	shaft
2	shaft
3	shaft
4	shaft
5	shaft
6	shaft
7	shaft
03	brake
04	brake
14	clutch
16	clutch
37	clutch
57	clutch
P1	planetary gears
P2	planetary gears
P3	planetary gears
An	drive
Ab	output
i	reduction
φ	step progression
G	housing